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GEOLOGIC INVESTIGATIONS IN SUPPORT OF PROJECT CHARIOT IN THE VICINITY OF CAPE THOMPSON, NORTHWESTERN ALASKA—PRELIMINARY REPORT

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GEOLOGICAL SURVEY

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*This report concerns work done on behalf of San Francisco Operations Office, U. S. Atomic Energy Commission.

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ABSTRACT AND GENERAL INTRODUCTION

By

Reuben Kachadoorian

Abstract

The Chariot test site at Ogotoruk Creek in the vicinity of Cape Thompson, Alaska, is topographically and geologically well-situated for the construction of an experimental deep-water excavation as proposed by the Atomic Energy Commission.

The rocks of the area consist entirely of consolidated clastic and chemical sediments of marine and brackish water depositional environments. They include sandstone, calcitic and dolomitic limestone, chert, argillite, mudstone, siltstone, and graywacke. All the rocks have been highly deformed and very slightly metamorphosed. The rocks range in age from Early Mississippian to Jurassic(?) and Cretaceous.

The material to be excavated consists chiefly of mudstone, siltstone, and sandstone of the Tiglukpuk formation of Jurassic(?) age. Test holes Able and Baker indicate that the devices will be located entirely in frozen mudstone containing numerous small faults. The fault zones in the mudstone

are generally less than 1 foot thick. In Hole Baker, however, there is a 14.1-foot fault zone from 136.2 feet to 150.3 feet below the surface. Locally, the mudstone is so highly fractured that it occurs as splinters 1/8- to 1/4-inch thick, 1/2- to 1-inch wide, and about 3 inches long.

During the drilling program in 1959 the walls of the holes slumped into the bottom of the hole when the relatively warm drilling fluid thawed the permafrost in the mudstone. Slumping of debris into the hole will be one of the major problems during the construction of the device holes if proper techniques are not utilized. The greatest amount of slumping will take place in the fault zones and the unconsolidated materials that overlie the mudstone if they are allowed to thaw.

The moisture content of the rocks in place probably is much higher than that reported by the Corps of Engineers for samples of the rock. The reported moisture content (0.28 to 5.67 percent) was based on thawed core sent to the Corps of Engineers laboratory in Anchorage, Alaska, and no consideration could be given to the fact that the rocks are perennially frozen and that some of the fracture zones may contain ice. It is believed that the moisture content is in the vicinity of 10 percent in the rocks that underlie the test site.

On the basis of preliminary geothermal data the tentative depth of permafrost in Hole Able is at least 800 feet below the surface and at least 1,000 feet in Hole Baker. The absence of reliable data concerning the lower half of Hole Baker makes it difficult to determine the undisturbed geothermal gradient below the zone of climatic change.

Seismic measurements in the frozen Tiglukpuk rocks indicate velocities ranging from 11,500 to 14,500 fps and averaging about 13,500 fps. Surface refraction measurements suggest a slight increase of velocity with depth, but

this increase with depth is not supported by the in-hole velocity logs. The drilling program planned for the summer of 1959 could not be completed, so that seismic velocities in the unfrozen mudstones beneath the permafrost could not be measured; therefore an attempt was made to measure by seismic refraction the depth to the high velocity chert and limestone that is believed to underlie the Tiglukpuk. However, this refraction work had not been planned previously and neither sufficient equipment nor time were available to obtain satisfactory results. Although a higher velocity was measured near the north end of a 7,500-foot profile, there is considerable doubt whether this higher velocity represents a deep refractor. If the high velocity does represent a deep refractor, its depth is somewhere between 1,000 and 1,750 feet.

The beach at the Chariot site is in a steady-state condition and is not advancing toward the land at a rate that is significant from an engineer's standpoint. Erosion behind the beach may be in the order of 1 or 2 feet a century. The net alongshore transport of sediments is approximately 5 cubic yards an hour to the southeast during the ice-free periods. However, during heavy storms the beach transport of sediments may be more than 1,000 cubic yards per hour. Therefore, jetties should be constructed on each of the excavated channels to accommodate the volume of material that may be moved during these storms.

Shallow and deep aquifers exist in the test site area. The shallow aquifers consist principally of unconsolidated material dependent upon recharge from surface sources during the summer. The deep aquifers are in permeable portions of bedrock and receive recharge water from distant sources. Both types of aquifers may be contaminated by any radioactive fallout from the proposed nuclear test. The shallow aquifers would receive contaminated surface water immediately, whereas it may take years for the deep aquifers to receive the contaminated surface water.

On the basis of data available the suspended sediment discharge of Ogotoruk Creek can be considered minor compared to the size of the proposed excavation. The chemical composition of the waters indicates springs as well as surface water exist in the vicinity of the test site. The radiochemical levels of the fresh waters are low and in the same magnitude as are normally found. The highest beta activity of the fresh waters was found in the two ponds approximately 6 miles north of the test site, and might be ascribed to fallout which has accumulated from previous detonations and which has not been flushed out owing to lack of natural drainage. The chemical composition of the water of the larger control pond to the east is unusual for the area, in that it has a high mineral content.

For all practical purposes no flow occurred in Ogotoruk Creek from October 1, 1958 to late in May 1959. There may have been some flow on certain scattered days but amounts were too small to be considered of any importance in the overall surface water study. No definite conclusions can be drawn from the limited stream-flow records obtained thus far, except that little flow is likely between mid-October and mid-May.

General introduction

General statement

In 1958 the U. S. Geological Survey was requested by the Atomic Energy Commission to conduct geologic studies to develop data which will contribute to determining the feasibility and safety of detonating several nuclear explosives to create an excavation that could be used for a channel and harbor near the mouth of Ogotoruk Creek, northwest Alaska. The proposed test excavation is Project Chariot of the Atomic Energy Commission's Operation Plowshare Program.

Previous work

In the early spring of 1958 the U. S. Geological Survey was asked to undertake a study to evaluate the geologic and oceanographic factors relevant to the selection of a site between Point Barrow and Nome, Alaska. Later, an area between Cape Seppings and Cape Thompson, Alaska, was selected and the Survey prepared a report on this 20-mile area (Péwé, Hopkins, and Lachenbruch, 1959). Péwé, Hopkins, and Lachenbruch's work was based entirely on the study of published reports, manuscripts, field notes, and unpublished maps in the files of the U. S. Geological Survey. This information was supplemented by interviews with geologists who had visited the area, and the geologic interpretation of aerial photographs. On the basis of the above sources of information, 3 sites were selected in the 20-mile coastal strip from Cape Seppings to Cape Thompson. The report suggested that a geological field investigation of the 3 sites be made to determine the most suitable site for the test.

Accordingly, a Survey field party worked in the area from July 7, 1958 to August 25, 1958. The data collected on the 3 sites were discussed with representatives of the Atomic Energy Commission, Lawrence Radiation Laboratory, Sandia Corporation, U. S. Corps of Engineers, and Holmes and Narver, Inc., who visited the Survey party from July 17 , 1958 to July 19, 1958. On the basis of the Survey findings it was decided to conduct the test at the Ogotoruk Creek site. A report was prepared by the Geological Survey and transmitted to the Atomic Energy Commission during the winter of 1958 (Kachadoorian, Campbell, Sainsbury, and Scholl, 1958). This report and the report by Péwé, Hopkins, and Lachenbruch were placed on open-file in October 1959 by the U. S. Geological Survey.

Present work

This report includes the Geological Survey's participation in the investigation of the Ogotoruk Creek test site area during the 1959 field season. This entire phase of the investigative program is referred to as Chariot, Phase II, by the Atomic Energy Commission. The Survey investigation for 1959 consisted of 6 parts: (1) site geologic investigations, (2) areal geologic mapping, (3) coastal processes investigations, (4) geothermal investigations, (5) seismic velocity investigations, and (6) water resources investigations. The seismic velocity investigations, in turn, were in two categories: in-hole velocity and a seismic refraction investigation. The water resources investigation was in three categories: surface water, ground water, and quality of water investigations. The seismic refraction study was not in the original Geological Survey proposal for field work for 1959, but was begun in the field when it became apparent that in-hole velocity equipment could not provide needed information on seismic velocities of the rocks at depths to 1,500 feet because the diamond-drilling program would not give required depth of 1,500 feet.

All pertinent major problems that are associated with the Geological Survey investigations are considered in this preliminary report. Some revisions may be necessary when complete laboratory results have been obtained, but the authors believe that these revisions will be slight and will not materially affect the conclusions expressed in this report.

Acknowledgments

Field work was facilitated by the cooperation of the personnel of the Atomic Energy Commission, Wein Airlines, Holmes and Narver, Inc., Boyles Bros., and Lawrence Radiation Laboratory.

Location

The Chariot site area lies north of the Arctic Circle in northwestern Alaska at longitude 165°45' W. and latitude 68°06'N., at the mouth of Ogotoruk Creek (fig. 1). The area is approximately 125 miles northwest of the town of Kotzebue and about 24 miles southeast of the town of Point Hope. The coastal processes investigation included the coastline from Sheshalik Spit, 110 miles southeast of the test site, to the mouth of the Kukpuk River, 27 miles northwest of the site.

Accessibility

The only means of access to the Ogotoruk Creek area at the present time is by boat, light aircraft, or tracked vehicle. The Alaska highway system does not extend into northwestern Alaska. Light single-engine aircraft can land at the site on a 700-foot airstrip built by the U. S. Geological Survey personnel in 1958. Twin-engine aircraft can land on a 2,200-foot airstrip constructed by the contractor, Holmes and Narver, Inc., in 1959.

Methods of field work

Onshore field work by the Geological Survey consisted of a series of foot, tracked vehicle, and boat traverses, during which geological data were gathered and plotted on vertical aerial photographs of 1:40,000 and 1:12,000 scale and on surface photographs ranging in scale from 1:600 to 1:3,000. The information was later transferred to topographic maps (pls. 1 and 2, respectively). Information concerning the depth of permafrost and thickness of ice wedges was obtained from diamond-drill holes.

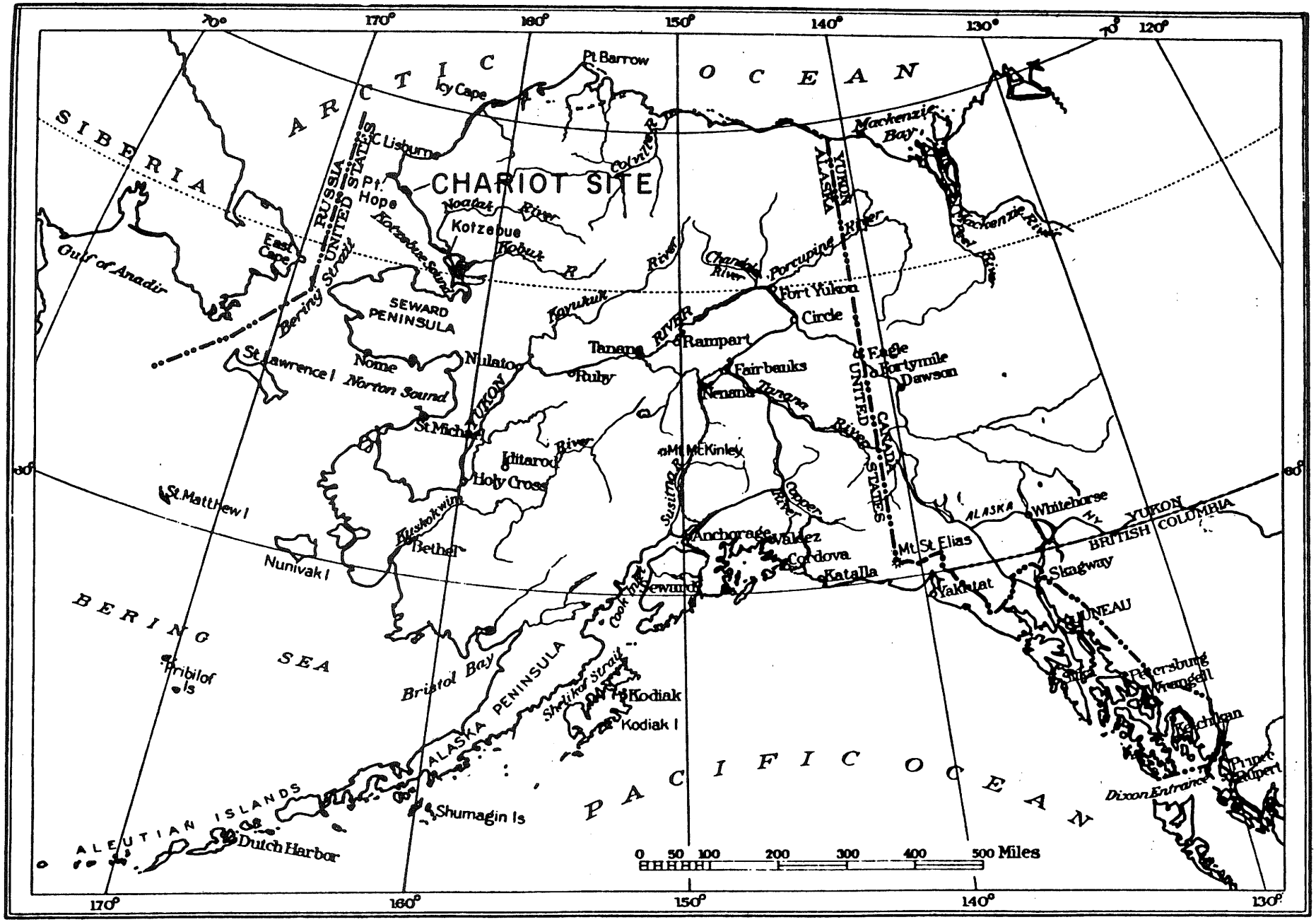

Figure 1.--Index map showing location of Chariot site, northwestern Alaska

Data regarding submarine topography, marine geology, oceanography, and coastal processes were collected by teams using either a weasel, or a small boat equipped with an outboard motor.

The Survey party included three two-man field teams. One team worked from Sheshalik Spit to the Kukpuk River doing the coastal processes investigation; the second team did the areal mapping; and the third team did the site investigation study. In addition to the three two-man field teams, Survey personnel doing the geothermal, ground water, surface water, and seismic investigations were also at the site from time to time.

Climate

The climate of the Ogotoruk Creek area is characterized by long cold winters and short cool summers. Data from weather stations at Kotzebue Airport, and Cape Lisburne about 70 miles north of Ogotoruk Creek, are shown in tables 1 and 2. Additional data for dates of freeze-up and breakup of ice are available for Kivalina, 30 miles southeast of Ogotoruk Creek, and Point Hope, and are shown in table 3.

Weather data have been collected by the Geological Survey at Ogotoruk Creek for the past two field seasons. Wind direction, maximum and minimum temperatures, and precipitation were recorded. The summary of these data is shown in table 4.

Literature cited

Kachadoorian, Reuben, Campbell, R. H., Sainsbury, C. L., and Scholl, D. W., 1958, Geology of the Ogotoruk Creek area, northwestern Alaska: U. S. Geol. Survey TEM-976; also, U. S. Geol. Survey open-file report.

(Text continued on p. 19)

Table 1.--Climatological data for Kotzebue Airport, Alaska [1/]

Month	Average temperature °F	Average precipitation inches
January	-6.6	.47
February	-4.7	.32
March	-1.6	.27
April	13.8	.36
May	29.6	.33
June	43.3	.49
July	52.6	1.53
August	50.7	1.95
September	40.9	.94
October	25.5	.58
November	7.5	.43
December	-3.7	.35
Annual	20.6	8.02

1/ U. S. Weather Bureau, 1958, Climatological data, Alaska Annual Summary, 1957, v. XLIII, no. 13

Years of record:

Precipitation, 15 years

Temperature, 15 years

Table 2.--Climatological data for Cape Lisburne, Alaska [1/]

Month	Average temperature °F	Average precipitation inches	
January	-9.5	.27	
February	-10.6	.13	
March	-8.7	.25	
April	20.9	.21	
May	30.3	.02	
June	41.6	.44	Partly estimated
July	46.0	2.12	
August	44.9	3.50	
September	35.8	2.61	
October	28.2	1.94	
November	5.9	.44	
December	-8.2 (1-10 days record missing)	.12	
Annual	19.7	12.05	Partly estimated

1/ U. S. Weather Bureau, 1958, Climatological data, Alaska Annual Summary, 1957, v. XLIII, no. 13

Years of record:

Precipitation, 3 years

Temperature, 4 years

Table 3.--Miscellaneous climatological data for Kotzebue, Cape Lisburne, Point Hope, and Kivalina, Alaska, 1957 [1/]

Station	Rivers and harbors	Date unsafe for man [2/]	Break-up	Departure [3/]	First ice	Date safe for man [4/]	Departure [3/]	Highest temp (°F)	Date	Lowest temp (°F)	Date	Total snow fall (in.)	Freezing temp: Last date in spring	Freezing temp: First date in autumn	Number of days temperature: Max. 70°F or above	Max. 32°F or below	Min. 32°F or below	Min. 0°F or below
Kotzebue	Kotzebue Sound	May 25	May 26	-6	Sept. 25	Oct. 31	+8	81	June 8	-47	Dec. 26	77.2	May 31 (30°)	Sept. 19 (32°)	5	183	243	90
Cape Lisburne	---	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	72	July 11	-37	Feb. 13	30.3	June 20 (32°)	Sept. 17 (28°)	1	195	247	104
Kivalina	Walik River	[6/]	[6/]	[6/]	Oct. 4	Oct. 8	-18	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]
Point Hope	Marit Inlet	May 30	June 9	[6/]	Sept. 26	Oct. 3	-8	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]	[5/]

1/ U. S. Weather Bureau, 1958, Climatological Data, Alaska Annual Summary, 1957, v. XLIII, no. 13.
2/ Date man cannot travel on ice.
3/ Departures are days from average date of breakup or freeze up based on five or more years of record. Earlier-than-average dates are indicated as minus and later-than-average dates are indicated as plus.
4/ Date man can travel on ice.
5/ No data reported by Weather Bureau.
6/ No record.

Table 4.--Summary of weather data for the Ogotoruk Creek area collected during 1958 and 1959 field seasons

	July 7-31 1958	July 13-31 1959	August 1-27 1958	August 1-31 1959
Total precipitation	0.4 in.	0.8 in.	4.4 in.	1.4 in.
Maximum precipitation in 24 hours	0.2 in. (July 9)	0.7 in. (July 23)	1.0 in. (Aug. 10 and 11)	0.5 in. (Aug. 22)
Maximum temperature	80°F (July 10)	79°F (July 20)	70°F (Aug. 27)	81°F (Aug. 13)
Average maximum daily temperature	63.5°F	57.9°F	60.2°F	59.3°F
Minimum temperature	35°F (July 27)	31°F (July 27)	34°F (Aug. 19)	34°F (Aug. 24 and 25)
Average minimum daily temperature	44.4°F	47.0°F	42.7°F	41.0°F
Average daily wind velocity	14 mph	14 mph	17 mph	16 mph
Maximum wind velocity	30 mph SE	30 mph NE	60 mph N	50 mph N
Average daily cloud cover	60 percent	55 percent	65 percent	50 percent
Number of essentially cloudless days	7	7	7	7

Literature cited--continued

Péwé, T. L., Hopkins, D. M., and Lachenbruch, A. H., 1959, Engineering geology bearing on harbor site selection along the northwest coast of Alaska from Nome to Point Barrow: U. S. Geol. Survey, TEI-678; also, U. S. Geol. Survey open-file report.

U. S. Weather Bureau, 1958, Climatological data: Alaska Annual Summary, 1957, v. XLIII, no. 13

ENGINEERING GEOLOGY OF THE CHARIOT SITE NEAR CAPE THOMPSON, NORTHWESTERN ALASKA

By

Reuben Kachadoorian

Introduction

General statement

During the 1959 field season a two-man Geological Survey field party worked at Ogotoruk Creek, Alaska doing site engineering geology investigations. In addition, the party in cooperation with U. S. Coast and Geodetic Survey and Holmes and Narver, Inc. personnel, selected several seismic recording stations. The site investigation consisted chiefly of logging core from diamond-drill holes Able and Baker, giving geologic advice and counsel to other participants in the Chariot Program, and evaluating the site geologic investigations conducted by the Survey in 1958. In addition to the site investigation studies the engineering geology team at the Chariot site collected the water samples at Ogotoruk Creek and elsewhere, collected daily weather data, and performed and provided a coordination and liaison